

Prospective Electrical Power Balance of Siberia and Opportunities for Power Cooperation with the Countries of Northeast Asia

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Abstract

Recently electricity consumption is steadily increasing in Siberia. For the first time Siberia can become energy-shortage area. Energy experts consider different projects of development of generating capacities in territory of Siberia for the long term.

The projects of hydro power plants construction are the most efficient yet expensive projects in the East of Russia. The second priority direction of development of power are projects of state district power stations construction. Opportunities of export from Siberia are limited as backwardness of grids structure and absence of sufficient capacities, also perspective growth of power consumption inside region. The question on expediency of the electric power export remains disputable. For a substantiation is it necessary to carry out additional researches and full-scale calculations.

Keywords: *electricity consumption, capacity commissioning program, electrical power balance of Siberia, regional energy policy, export of electric power*

1. Introduction

Today the world's largest power market steadily develops in Asian-Pacific region (APR) which includes countries with high rates of economic development and great demand for power resources.

Power cooperation between Russia and of some the countries of Northeast Asia is currently developing successfully and has good prospects in foreseeable future. The decision has been made to build an oil pipeline system from Eastern Siberia to the Pacific coast with branches to China. Realization of the project will create a substantial growth in volume of distribution of Russian to China.

Natural gas is another perspective direction for cooperation. Various options for delivering gas from Western and Eastern Siberia and the Far East to the countries

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of Northeast Asia are being discussed. Here too the foremost attention is focused on cooperation with China based on the framework of the agreement on strategic cooperation between Gazprom and the Chinese national oil-and-gas corporation. The foundation for this cooperation has already been started with Russia participating in construction of underground storehouses of gas in China, and of gas mains between the two countries.

The increase in deliveries of oil-and-gas resources to the countries of Northeast Asia will allow them to raise reliability and efficiency of their fuel and energy balance.

The third prominent aspect of power cooperation between the countries is in the establishment of export of the electric power from Russia. In this article we shall try to consider the potential of development of electric power industry in the East Russia and prospects of deliveries of this power to the countries of Northeast Asia.

Prospects of deliveries of the electric power from Siberia are close interrelated with potential growth of internal demand in region. Already now deficiency is observed in a number of subjects SDF. The big shortage is possible still further under condition of realization of large investment projects (oil, gas, metallurgical and other) and late putting into operation of new energy capacities. But it is necessary to note, that potential scales of commissioning stations and their perspective electricity generation are rather significant.

Let's consider the aspects stated above in more detail

2. General state of the electric power industry in the Eastern part of Russia

The electric power industry in the East of Russia includes two power supply systems - the Electric power pool of Siberia (the EPP Siberia) and the Electric power pool of the East (the EPP East), and also a number isolated energy districts. Actually the EPP Siberia and the EPP East also are isolated from each other and from the EPP of the Urals and the European part of Russia as intersystem power are now supported with low-voltage power lines.

Installed capacity the EPP Siberia is 45.5 GW, 49% of which are provided by hydroelectric power stations, with the rest provided by thermal power stations. In 2006 the region produced about 192 billion kWh. Long time the EPP Siberia was an excessive power supply system. However, due to the industrial growth in 2005 some Siberian regions were faced with a problem of shortage of the electric power, though it is necessary to note, that on the installed capacity in the EPP Siberia there was a surplus.

The installed capacity of power stations of the Far East makes 11.5 GW, from which 7.4 GW are located on a territory of the EPP East. In this region, power generation is dominated by thermal coal stations (81 % of installed capacity the EPP East). In the 2006 the pool produced about 34 billion kWh. Historically the EPP East was a deficient power supply system, and the shortage of power capacities was one of the reasons for the depression in Far East economy. Commissioning of four units of the Burejskaya hydroelectric power station in 2003-2005 and construction of high-voltage power lines have improved the power supply of the region.

The current reform of the Russian electric power industry determines the direction for investment activity in Siberia and the Far East. As a result of the reforms, in addition to the Federal Network Company and HydroOGK, there are now new independent companies in a

power supply system of Siberia, which are both objects and subjects of investment. A unique feature of the reforms of the energy industry in the Far East is a merger of generating and network actives of joint-stock companies into a unified Far East Power Company (with the State presumed to hold the controlling share) with internal division into specialized business units - "Generation", "Grids" and "Sales". As a result, the State will retain its position as the main player in electric power industry of the Far East, represented by the Far East Power Company and HydroOGK.

3. Problems of perspective balance

Energy experts still cannot come to an agreement regarding prospective solutions to the energy shortages in the Siberian Federal District, as well as regarding the existence of this problem altogether. Some assert that the Siberian Federal District presently has and will have in the near future a surplus of energy, while the deficit in certain territories is due to an insufficient energy distribution system. Noticeable deficit can arise only in case of large-scale energy export. Therefore, development of power distribution networks is the priority for the EPP Siberia.

Other experts claim that industry outgrowing energy supplies will result in foundering of national projects, failures of social and economic programs and decrease of investment appeal of Siberian regions. According to these experts, the energy deficit can be overcome by bringing online new generating capacities.

Unlike other branched of the economy in Russia in the transitional period, electric power industry did not stop an elaboration of long-term forecasts. In the document titled *Power Strategy of Russia for the Period till 2020*, which was approved by the Government of the Russian Federation in 2003, it was suggested that annual consumption in the country could increase up to 1015 bln kWh by the year 2010, and by 2020 be up to 1215 bln kWh even with a moderate rate of economic development. With an optimistic rate of economic development, the annual consumption could reach 1070 bln kWh by 2010, and 1365 bln kWh by 2020. In this optimistic scenario, the annual power consumption in Siberian Federal District is projected to reach 234 bln kWh by 2010, and by 2020 - 314 bln kWh.

Experts of the Siberian Branch of the Russian Academy of Science criticized these forecasts, arguing that they underestimated the potential rate of economic development of Eastern regions of the country, while overestimating the rate of possible energy conservation. Our analysis of the future electric power situation showed that by the year 2010, the parameters accepted in the *Strategy* for development of generating facilities will be insufficient, when it comes to providing the energy necessary for economic development of the Siberian Federal District. Even with the highest possible rate of energy conservation in region (about 25 % of the existing consumption) and wide modernization of the basic power equipment and electronics, by 2010 there could be energy deficit in the region, even without taking into account deliveries of electricity from the EPP Siberia to the European part of Russia and to export.

Later on, there was a significant change in the outlook of federal government on the prospects of economic development in general, and energy development in particular. Now,

the main document determining the direction of development of energy in Russia is the *Project of the General Scheme of Allocation of Objects of Electric Power Industry for the Period till 2020* (further, the *General Scheme*). Development of the *General Scheme* was based on two scenarios set by the Russian Government: one for a conservative and another for an optimal case of social and economic development, including the corresponding figures for energy generation needs.

Based on the conservative scenario of the *General Scheme*, the need for the electric power in Russia as a whole would be 1710 bln kWh by 2020, and based on the optimal scenario it would reach 2000 bln kWh, which is 40 % greater than predicted by the *Power Strategy of Russia for the Period till 2020* for the conservative scenario, and 46 % greater for the optimal scenario.

According to forecasts of the *General Scheme*, energy consumption in Siberian Federal District (SFD) would grow at a rate of 4.7 %. At such a rate, the need for electric power would increase by 70.7% in the period from 2006 to 2020, and could reach 341.9 bln kWh by 2020 even in the conservative scenario.

We believe these projected numbers an overestimation, as rates of growth of power consumption in Siberian Federal District from 2005 to 2006 are unreasonably extrapolated for the period from 2007 to 2015, and do not agree with perspectives for economic development. Calculations using economic-mathematical tools developed in IEIE SBRAS show that industrial production will remain the greatest consumer of electricity in Siberian Federal District. In 2005 its share (excluding the internal needs of electric power industry) was more than 56% of the total power consumption, and in some of the areas of Siberian Federal District regions these numbers are even higher. Industrial production will not only retain but it will increase its role of the main consumer of electricity for the forecasted period. This would be caused by the needs of some large-scale investment projects of power-demanding industries planned in Siberia (more than 55 % of a pure increase of the total power consumption predicted by 2020).

In the foreseeable future there are plans for a creation of a new center of the oil-and-gas industry in Eastern Siberia, a construction of an oil pipeline «Eastern Siberia - Pacific Ocean», a construction of gas-chemistry complex based on Kovykta gas deposits, a development of coal deposits in Western and Eastern Siberia, a realization of projects in Kodaro-Udokansky mineral and raw materials complex, and bringing online of Boguchansky and Tayshetsky aluminum plants, of Novosibirsk metal plant, of several pulp-and-paper factories and others.

By our estimations, based on realization of new investment projects in some industries and progressive development of other consumers, demand for electricity in the Siberian Federal District in 2010 will be in a range of 222-259 bln kWh, and in 2020 in a range of 280-355 bln kWh, which is lower than forecasted by the RAO UES.

4. Prospects of production of the electric power

The predicted demand for installed capacity will be fulfilled by:

- Modernizations and expansions of capacity of working power stations of all types;

- Commissioning of new capacities at thermal power stations (coherent energy unit thermal power stations and condensation stations of significance);
- Commissioning of new capacities at power stations of other types – hydro, atomic and nonconventional power plants.

Investment priorities in electric power industry are defined by technical conditions of main facilities, by the cost-price of energy carriers, by local shortages in electric and thermal energy, by network restrictions, and by the limited availability of long-term investments. Thus, most of the current commercial investments are focused on the least costly projects, such as modernization and re-equipment of operational power stations, and on completion of "long-term constructions" of the last century. Further development of electric power industry of Eastern Russia in many respects would be defined by investment plans of the state corporations, which does not exclude investment on the part of private companies.

An important direction of energy development will be focused on bringing up the operational power stations (mainly thermal) to the designed capacities. The most capital-intensive investment projects are focused on construction of new power stations, both thermal and hydroelectric. The majority of new projects are directed at a satisfying the likely increase in power consumption inside the country; however, there is also a number of projects planned for long-term future export deliveries of the electric power.

Potential capacities for maintaining the existing power stations in operation are defined by two major factors: technical condition of aging equipment and the comparative efficiency (comparison of prolonging the terms of operation of the existing equipment and its full replacement by new, technically progressive equipment.)

Reconstruction and modernization of stations will increase the overall capacity by 0.3 GW by 2010 and by an additional 1.8 GW by 2020, which will be less than 6% of the total amount of the increase of the installed capacity. It is obvious, that by reconstruction of the existing stations alone, it is impossible to satisfy the growing needs, and new stations are required.

The most efficient yet expensive projects in power industry in the East of Russia, are the projects of hydro power plants. The foremost object of investments in the Eastern Russia is the completion of Bureyskaya (the Amur area) and Boguchanskaya (Krasnoyarsk region) hydroelectric power stations. Such investments are necessary to satisfy the growing needs of large energy-demanding projects in the East of Russia, as well as to increase export of the electric power. Companies HydroOGK and Rusal have made the decision to jointly finish construction of Boguchanskaya hydroelectric power station as a part of Boguchanskaya electrometallurgical group. At present the station is estimated to be 55% complete. This hydroelectric power station will produce 17.6 billion kWh of electrical power with capacity of 3000 MW by 2012. The completion of Boguchanskaya hydroelectric power station is estimated at 1.5 billion dollars. Taking into account design and construction, the station should come online between 2016 and 2020. Besides Boguchanskaya HPP, only two medium-sized HPPs could be brought online between 2011 and 2015, Katunskaya in Altai territory and Krapivinskaya in the Kemerovo area. In the more remote future there are considerations for construction of other hydroelectric power stations, such as Mokskaya HPP in Republic

Buryatia (1410 MW), the cascade of Nizhneangarskie HPPs in Krasnoyarsk region (3580 MW), the Altayskaya HPP and others.

In addition to that, HydroOGK considers possibilities for construction of powerful Turuhanskaya HPP in Krasnoyarsk region, with its primary goal being to supply power to the Urals and the European part of Russia. The station is expected to have 12 turbines, each with a capacity of 1000 MW. The required investments are estimated at 11.9 billion dollars. At the designed capacity, Turuhanskaya HPP will produce 46 billion kWh of electricity annually.

The majority of plans for the described HPPs are projected to be completed after 2012, which cannot satisfy the needs of the Siberian Federal District for the previous period. Based on the power consumption in SFD going up to 16-29 bln kWh by 2010, the HPPs may satisfy less than 20% of the demand, and that is only if speed of construction exceeds expectations. In the long-term, past 2020, the new hydrostations may fulfill up to 25% of the demand for electricity.

At this time, the majority of Siberia's electric power is produced by thermal stations: in 2005 their volume of production was 95.3 billion kWh (or 50.8 % of total output). The share of production of combined heat and power plants (CHPPs) has exceeded 66 % among thermal stations, which is based on the great demands for thermal energy due to the cold climate and the high efficiency of the combined generation of electric and thermal energy.

But in the long term, the needs for thermal energy will increase much slower than those for the electric power. Besides, there are now favorable conditions for faster development of local and independent energy generation. Therefore, expansion of thermal power stations is going to be considerably less in the future. As a rule, their future development falls to territorial generating companies (TGC).

In Irkutsk there are plans under consideration for expansion of existing coal stations (New-Irkutskaya, New-Ziminskaya and Ust-Ilimskaya combined heat and power plants) totaling 690 MW, producing additional 4 billion kWh, with the cost of 664 million dollars. In total, industrial bases of Irkutsk thermal power stations are able to accommodate for up to 2000 MW in additional capacities (about 11.4 billion kWh per year).

In the Kemerovo area are considered projects of additional capacity commissioning of 800 MW on the platforms of Kuznetsk thermal power station and New-Kemerovskaya CHPP.

In Novosibirsk area there are plans to build Novosibirsk CHPP-6 with a capacity of 750 MW, which would annually produce 3.89 bln kWh of the electric power and 5.22 million Gcal of heat.

In Krasnoyarsk territory it is essential to complete the construction of Sosnovoborskaya thermal power station, which has a capacity of 800 MW, and of Krasnoyarskaya CHPP-3 with a capacity of 540 MW.

In Omsk there are plans for construction of Omskaya CHPP-6 with a capacity ranging from 300 to 600 MW, which will require an investment of 350-740 million dollars in the next 5 years. Realization of this project will partially fulfill the regional needs in heat and electric power.

Within the framework of the project to expand capacities of Tomskaya CHPP-3 there

is plan to input two gas and one steam-to-gas turbines that will increase the capacity by 450 MW and annual generation of electricity by 2.6 bln kWh.

In Altai territory, construction of the Barnaulskaya CHPP-4 is essential due to shortage of capacities in region. The project calls for construction of thermal power station with capacity of approximately 310 MW, which would increase the volume of annual production of the electric power in the territory by 2.3 bln kWh and by 4.1 million Gcal of heat. Investments into the project within 6.5 years should amount to 110-160 million dollars.

The increase of capacities of combined heat and power plants will satisfy only a small share of the increase in total demands for the electric power in Siberia (by 2010 - about 30 %, by 2020 - 15 %). The main factor in satisfying the increasing needs will be construction of new large SDPPs (State District Power Plants.)

For ecological reasons some thermal power stations located near gas supply systems are expected to run on gas. However, the overwhelming share of the new capacities of the State District Power Stations during the entire period will be based on coal power stations (using Siberian coal - Kansk-Achinsky, Kuznetsky and Transbaikalian), which will be the case both in eastern and the western part of region. Construction of new SDPPs and expansion of the existing ones are both being considered. Between 2011 and 2020, 13 new large State District Power Stations should be brought online, producing 19.6 GW under low demand conditions, and 34.1 GW with maximum demands. It would make up 54% and 63% accordingly of total new capacities of all stations in SFD.

Gusinoozerskaya SDPP (Republic Buryatia) has the installed capacity 1100 MW that would produce 3 bln kWh annually. Within the framework of the further development and increase of efficiency of power station it is planned to carry out both modernization, and construction of new generating capacities that would allow to increase capacity by 840 MW and generation of the electric power by 4.7 bln kWh annually. Investments into new construction will be over 550 million dollars.

Berezovskaya SDPP-1 (Krasnoyarsk region) produces about 6.2 billion kWh of electricity annually at the installed capacity of 1500 MW. There is a plan to complete construction of two power units with a capacity of 660 MBt by 2015, which will increase its annual power generation by approximately 4 billion kWh. Additional 2 blocks with total capacity of 1320 MW should be launched by 2020.

Kuzbassrazrezugol is reviewing a possibility of building a power station with a capacity of 500 to 1500 MW in close proximity to one of its cuts. Investments for this project be 1 to 2 billion dollars.

In addition to Novosibirskaya CHPP-6, Novosibirsk region is planning to build a state district power station with a capacity of 1200-3000 MW, generating approximately 6-13 billion kWh of electricity. Costs of the project are tentatively estimated at 1.2-4 billion dollars.

Another thermal station with a planned expansion (increase in capacity by 225 MW) is Haranorskaya state district power station located near the border, which will allow export of some of its electrical power to Mongolia and China.

Other proposed export-focused generating sources in Siberia include power units at New-Haranorskaya SDPP (3x800 MW), Tataurovskaya SDPP (2x600 MW) and Olon-

Shibirskaya CHPP (4x900 MW).

5. Current and prospective structure of the installed capacity

Currently the make-up of power generation in Siberia differs from that of the Russia, as it is represented only by HPP and TPP. The atomic energy was never developed in Siberia due to abundance of gas and coal. The nonconventional power was not widely spread either, appearing only in some isolated regions in a form of the small water-powered generation and geothermal energy.

In the projected period Rosatom has proposed construction of two blocks, 1150 MW each, at an atomic power station in the Tomsk region. This station is oriented on using infrastructure and experienced force resources of Seversky Chemistry industrial complex. Its energy will be delivered to European part of country. In strategy of development "Rosatom" there are no another plans on construction of other nuclear stations in Siberia.¹

Table 1 shows the changes in the capacity of power stations of different types in Siberian FD, stipulated by the *General Scheme*.

Table 1 - The Installed Capacity of Power Stations in the Siberian Federal District (in the Centralized Zone of Electric Supply)

	2005	2010	Moderate Rate		Maximal Rate	
			2015	2020	2015	2020.
Total, GW:	45.8	49.6	64.7	79.4	72.9	97.3
Hydroelectric power stations	22.3	24.3	25.7	30.9	26.0	34.3
Atomic power stations			1.2	2.3	1.2	2.3
Thermal power stations:	23.6	25.3	37.8	46.2	45.7	60.7
Combined heat and power plant	15.6	16.4	16.9	19.5	16.9	19.5
State district power plant (SDPP)	8.0	8.9	20.9	26.7	28.8	41.2
Total, %:	100.0	100.0	100.0	100.0	100.0	100.0
Hydroelectric power stations	48.6	49.0	39.8	38.9	35.7	35.2
Atomic power stations			1.8	2.9	1.6	2.4
Thermal power stations:	51.4	51.0	58.5	58.2	62.7	62.4
Combined heat and power plant	34.0	33.1	26.1	24.6	23.2	20.1
State district power plant (SDPP)	17.4	17.9	32.4	33.6	39.6	42.3

¹ As a whole across Russia extensive enough plans on input of new nuclear capacities, but basically in the Central and Southern districts of the country are planned. In Siberia due to presence of sufficient stocks of coal it is planned inputs of coal generation.

6. *Development of electric grid facilities*

For reliable supply of the electric power to consumers, it is necessary to observe a principle of reasonable redundancy of an electric network infrastructure. Currently, the connection between the European part of Russia and East regions is lacking. In 90ies due to economic restructuring and disintegration of the USSR, the main high-voltage electric transmission facilities stayed on the territory of Kazakhstan, and the early construction of northern link high voltage line has been suspended for the lack of funding. In the recent years in Omsk area a construction of lines of a high voltage was begun, which will allow to somewhat solve the problem of isolation Siberia EPS, and will provide an opportunity to transfer the electric power to the European part of the country.

Key objects of development of a network infrastructure in the East Russia is construction of gateways electric high voltage transmission facilities (750 kV and is higher) in a direction Siberia - Ural and Siberia - the East, which will allow to overcome the isolation of the Siberian and Far East power supply systems. Intersystem communications Siberia - the East are supposed to run along the lines of Gusinozerskaya SDPP - Chita - Zeyskaya HPP, Bratskaya HPP - Tynda - Zeyskaya HPP and Ust-Ilim HPP - cascade Viljujskie HPPs - Yakutskaya SDPP - the Kolymskaya HPP. During the period ending 2020, a unification of Siberia EPS and East EPS is planned.

During 2011-2020 in order to get the capacity and electric power TPPs and HPPs of Siberia involved into the fuel and energy balance of the European part of the country, it is planned to build direct current transmission facilities with a voltage of ± 500 kV and ± 750 kV. There will be a ± 500 kV line Siberia - Tyumen, with a throughput of 2000 MW, stretching for 900 km; a ± 750 kV Siberia - Ural - the Center, throughput of 3000 MW, 3700 km long; and two ± 750 kV lines from Evenkskaya HPP to Tyumen, with a throughput of 2000 MW, 600 and 800 km in length.

Realization of the largest designated energy construction projects will allow to increase the installed capacity of power stations of the East of Russia by 34-53 GW (by 2/3 from present), and generation of electricity by 185-223 bln kWh annually (practically to double) by 2020. However, this will require an investment of over \$40 bln, or nearly \$3 billion a year. We shall note, that completion of just the already started projects (without new construction) within the first 10 years with investments of about \$7 billion, will increase the installed capacity by 9 GW, and productions of the electricity by more than on 50 billion kWh annually.

7. *The forecast of export of the electric power*

International cooperation, development of the new power markets and use of international experience, are the main directions of foreign policy of Russian Government in energy sector.

In 2005 consumption of electricity in Japan was 1230 bln kWh, in South Korea - 650 bln kWh, in China - 2400 bln kWh. According to the forecast of International Energy Agency till 2010 the power consumption in these countries will grow by 5-10 % annually.

Despite the large-scale input of new electric generating capacities planned by these countries, it is hardly possible to fulfill the demands by internal capabilities alone. Export of electricity from Eastern regions of Russia can partially satisfy the growing needs.

According to the statistical data total export from Russia (balance without taking into account border trade) was 6 billion kWh in 2004, in 2005 – 11.2 bln kWh, in 2006 – 15.6 bln kWh. In 2006 the share of export of electricity that went to the East (China and Mongolia) was about 3 % or 696 million kWh.

Export-focused power facilities of the Far East will deliver electricity to countries such as Japan, South Korea, China, etc. Siberian electric power is mostly destined for China.

The first time electric power deliveries from Russia to China were proposed was by company Irkutskenergo in the mid 90s. To achieve this a construction of power line 2600 km long connecting Irkutsk to China was required, but in 1999 negotiations stalled.

Currently, RAO UES is exporting electric power to China within the framework of “border trade”. In 2006 supply of electricity from Russia to China has reached 522.91 mln kWh, which is 30.98 mln kWh greater than it was in 2005.

In the recent years the Chinese side is showing interest in evaluation of possibilities for a significant increase in the imported Russian electric power. The consumption in China in 2005 has risen by 10.5 % and reached 2.4 bln kWh, and in 2006 it reached 2.7 bln kWh. The country is carrying out a program to transfer electric power from Western to Eastern of China, and to create a nationwide system. The launch of this unified nationwide electric system is planned for 2010. High rates of economic growth will cause a further growth of a consumption of electricity. The increase in consumption is based mainly on industrial development. Urbanization is another important factor in the rapid growth in energy needs. The state measures of macro-control and regulation may slow down the rates of increase of electricity consumption in China, but they cannot stop them entirely.

In November 2006 RAO UES and State Grid Corporation of China have signed the Agreement on export of the electric power from Russia to China. The project includes three stages: during the first stage (2008 to 2010) Russia will deliver 3.6-4.3 bln kWh annually, during the second (2010 to 2015) - up to 18 bln kWh, and during the third (after 2015) - up to 38.4 billion kWh. Ultimately, RAO UES plans to reach 60 bln kWh in annual deliveries to China.

The forecast is that large-scale export of capacity and electric power to China from the EPS East will be provided by the existing power stations of the south of the Far East, starting in 2008 with a volumes of 0.75 GW and 4.5 bln kWh, and by 2012 reaching 3.75 GW and 22.5 bln kWh.

In addition to the EPS East, the EPS Siberia is also considered for large-scale exports to China. To fulfill the need in export-focused generating facilities in Siberia, new power units are being brought online at New-Haranorskaya CHPP, Tataurovskaya SDPP and Olon-Shibirskaya TPP. The beginning of large-scale export from Siberia is planned for 2015, with volumes of 6 GW and 36 bln kWh.

Geographically, deliveries of electricity are mainly targeting the Eastern China. A less technically developed direction is an alternative that would deliver electricity from the South of Western Siberia to Western China. Here it is possible to use the capacities of the

drafted for construction APP in Tomsk area and SDPP in Kemerovo area.

The volumes of export of electric power from the East of Russia are also being discussed. The agreed-upon amount of the electricity makes up more than 6% of all electric power generated in the country. Under the conditions of deficiency of electric capacity in certain regions, it seems risky to plan such great deliveries abroad. Emphasizing the development of export of electric power to China and creation of huge facilities to achieve this, the Russian side puts itself in strong and, potentially, unjustified dependence on a single importer, especially since the profits from these deliveries will not be very high.

The Chinese side shows itself as an extremely uncompromising partner as soon as the subject of the price of deliveries comes up. In March, 2006 the vice-president of the State Committee of China on development and reforms Zhan Gobao has noted, that Russia suggests to sell one watt for eight cents, which would be too expensive for China, since the internal cost of the electric power is four cents. However, Russia cannot sell it too cheaply because transportation demands investments. A cost of one kilometer of power line is estimated at approximately one million dollars. For now the sides have agreed to define the basic price of Russian electricity by basing it on the average price of electricity for trunks of power stations in receiving areas of China. As the Agreement states, the export price should provide both sides with acceptable economic efficiency and profitability timeframe.

At a first glance, for domestic and foreign investors the positive potential of the arrangements achieved in China is high enough. However, many things will depend on details of financing of new construction. The Chinese side is enticed into the project by Russia's abilities (and plans) to take on by itself the main risks of investment. But, in opinion of Institute of Problems of Natural Monopolies, the country being pulled into such a large-scale project will cause damage to a draw of investments into the energy industry of other regions, such as construction of generating capacities in the European part of the country. They suggest that at first it makes sense to at least fill available spare capacities with consumers of a given region, which can be achieved mainly by developing an industrial complex on its territory. It is possible to divert the overflow of the electric power to deficient regions; however, significant investments into the grid will be required, and this will result in turn in additional costs both for construction and for the subsequent operational expenses, let alone natural losses occurring in such long distance transfers of electricity.

However, this position appears disputable. The Institute of Problems of Natural Monopolies shows no data supporting the validity of their conclusions. In fact, in order to provide the deficient regions of the European part of Russia with energy by constructing their own generating capacities, great volumes of coal will have to be delivered from Siberia. Due to congestion of the Trans-Siberian railway, new latitudinal railway will have to be built, costing no less than construction of high voltage power lines. In addition, there will be great both operational expenses and losses occurring in transportation of coal. Therefore, a correct conclusion about economic feasibility of transfer of energy carriers on great distances can be reached only by comparison of alternatives within the framework of optimization of country fuel and energy balance.

As to evaluation of efficiency of export of energy from Siberia, we share the point of view of experts of Institute of National Power, who believe that in long-term the prospect of

export to China can be quite profitable, considering the enormous increase in consumption. China is gradually exhausting its cheap coal resources, which currently compose the overwhelming base of the Chinese energy industry.

As importers of the electric power from Russia mainly act and there will be further northeast areas of China. China would be able to get energy from somewhere except the Russian Eastern Area, but Russia undoubtedly has potential the largest the exporter in comparison with other countries of Asia.

The opportunity of deliveries to China from other countries of Asia is rather limited. India realizes frontier trade of electricity but promptly growing power consumption into country reduces considerably its export opportunities. Such countries as Republic of Korea, Japan and Thailand have no potential for escalating capacities of an export orientation.

Therefore, within 10 years China will have to buy more electric power from Russia, and do so at a price acceptable to both sides.

8. Conclusions

1. From this analysis it is apparent, that experts agree on a significant increase in the future volume of power consumption, while the estimates of size of this increase vary a little.

While developing the *Power Strategy*, the figure of 314 billion kWh was accepted as the volume of power consumption of the Siberian Federal District by the year 2020. According to experts IEIE SBRAS this volume is underestimated. By our estimations in 2020 it can be 280-355 billion kWh. Later the opinion of federal administrators has drastically changed in regards to the prospects of development of economy in general and energy in particular. According to the *General Scheme*, power consumption in Siberia can reach levels of 341-438 billion kWh by 2020, which in our opinion is an exaggerated estimate. The problem of potential energy deficit in the East of the country should be discussed on the basis of comprehensive power balance of SFD and the Far East, conducted by unbiased experts taking into account forecasts of economic development tendencies of federal districts.

The share of large projects can make up 36 % to 60 % of total increase of power consumption in SFD. Depending on their completion, by 2010 the increase in consumption can be 9 billion kWh with the minimum number of projects, and 45 billion kWh with the maximum.

2. If there are no investments into new networks and power stations today, tomorrow shortage of the electric power will become an obstacle for development of industry and entire economy of Siberian region. In order to overcome the arising predicament of electric power in SFD, it is essential to either reconsider the list of power-consuming industries planned for construction, or to undertake a more vigorous development of generating sources.

The *Project of the General Scheme of Allocation of Objects of Electric Power Industry for the Period till 2020* is focusing on the second option. In order to satisfy the growing need for energy in the Eastern part of Russia, new capacities are planned to be

brought online, which will allow to increase the installed capacity of power stations in the East of Russia by 34-53 GW (by 2/3 of the present) and production of the electric power by 185-223 billion kWh annually (practically to double) by 2020. It seems that addition of capacities at such rate is overestimated, since that would require to master \$3 bln annually in investments.

3. In addition to the Far East, Siberia is also considered as a source of large-scale exports of capacity and electric power to China. Although process of negotiations between the Russian and Chinese sides cools down at times; nevertheless, work still proceeds to amend the Agreement on prospective volumes, the price of electric power and directions of deliveries.

In the beginning large-scale exports from Siberia are seen at a level of 6 GW and 36 bln kWh by 2015. Power units on New-New-Haranorskaya, Tataurovskaya and Olon-Shibirskaya TPP are being brought online as export-focused generating facilities of Siberia. Geographically, deliveries of the electric power are mainly targeting the East of China. A less technically developed alternative direction of export is that from the South of Western Siberia to the West of China. On this route it is possible to use the electric power generated by the atomic power station in Tomsk area and a state district power station in the Kemerovo area, where construction is planned to begin.

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